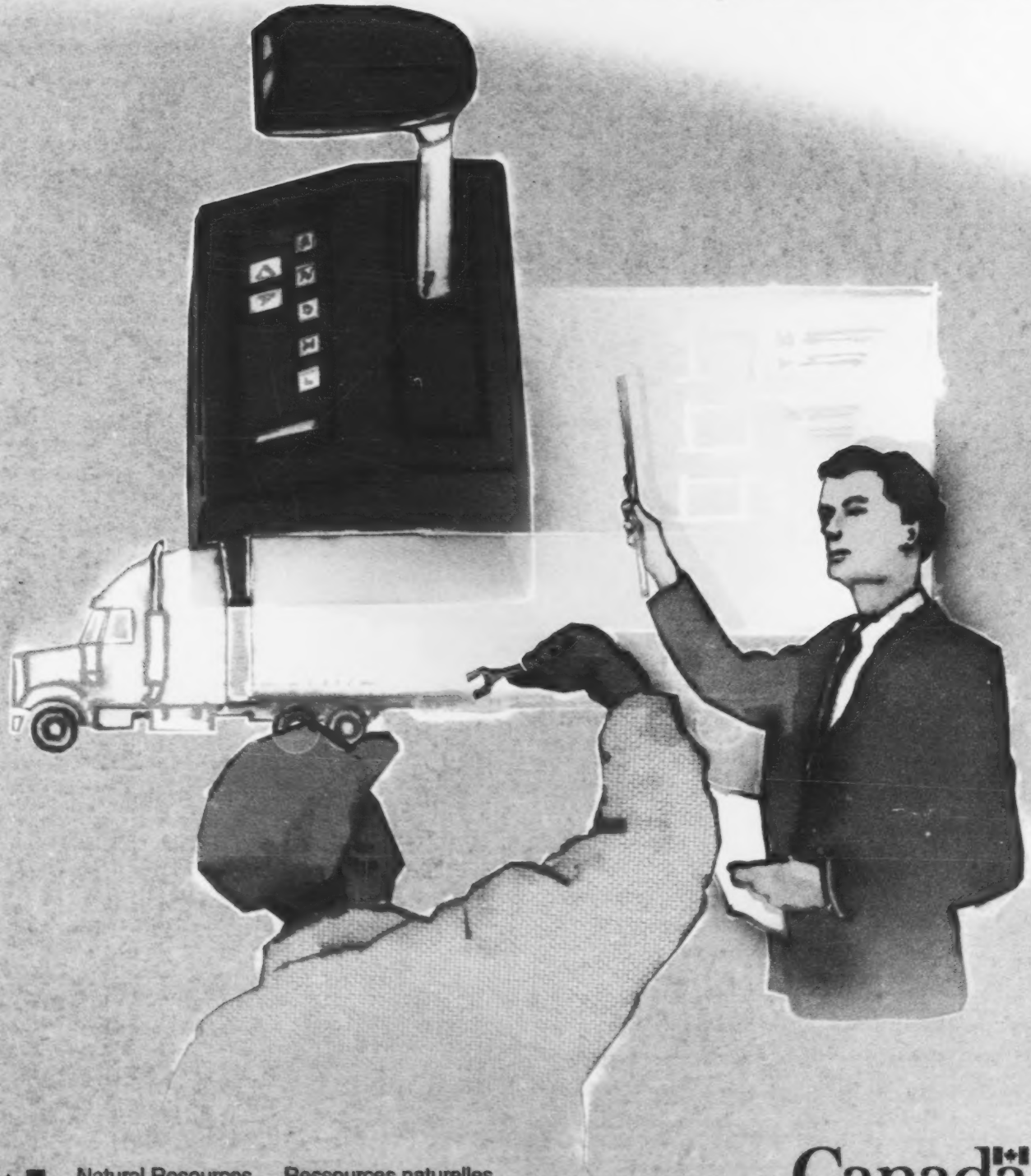
FleetSmart Program

Technical Evaluation of Automatic-Type Transmissions for the Heavy Truck Market



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FleetSmart

Technical Evaluation of Automatic-Type Transmissions for the Heavy Truck Market

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FleetSmart Program

FleetSmart works with fleet and industry associations to help reduce fuel costs and vehicle emissions through energy efficiency in order to help address the challenges of climate change. FleetSmart also develops energy use data and profiles for fleets and provides a range of services, including energy management information and SmartDriver training for professional drivers. Visit our Web site at http://oee.nrcan.gc.ca/fleetsmart.

Technical Evaluation of Automatic-Type Transmissions for the Heavy Truck Market

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1.0 INTRODUCTION

Selecting a transmission has become more complex and involves an increasing number of choices. Not only must operators of fleets of class 7 or 8 trucks decide on the usual factors such as manufacturer and number of speeds, they can also choose between manual and automatic gearboxes. Selecting a transmission must be done carefully as their choice will have a great impact on the environmental and energy performance of their heavy vehicles. It should be noted that fuel is the second greatest expense for road transport fleets and may represent between 12 and 30 percent of a fleet's costs, depending on the type of operation and the level of energy efficiency obtained.

Some fleet operators have already purchased vehicles with automatic-type transmissions, and many others are considering this as a valid option for new truck purchases. As there are only a small number of truck fleets using this technology, many professional truckers remain skeptical.

The objectives of this technical report are as follows:

- To identify transmissions that are currently available or in development for class 7 and 8 vehicles;
- To determine technical parameters as set by gearbox manufacturers;
- To compare the different types of transmissions;
- To evaluate transmissions based on fleets using manual and automatic types;
- To identify technical parameters to aid fleet operators in selecting a transmission; and
- To prepare a technical report to be used subsequently by the client for publication purposes.

Currently there are over 20 000 heavy trucks with automatic-type transmissions in North America, which is less than one percent of the total stock of class 7 and 8 vehicles. However, this technology is moving ahead rapidly, especially with the scarcity of professional drivers in some sectors.

Among the provinces of Canada, Quebec has the greatest number of users of this technology. For this reason, our fleet survey will cover both public and private operations based in Quebec, although their trucks operate in many regions of North America.

2.0 Methodology

This project covers new technologies for which very little documentation exists. Therefore, the author had to contact the transmission manufacturers and fleet operators using the transmissions.

Through co-operation with one manufacturer and a training facility, the author was able to see the technology in action and evaluate it. One of the members of the demonstration team holds a class 1 licence and has considerable driving and training experience involving class 7 and 8 heavy vehicles.

Following the demonstration, transmission manufacturers were contacted to obtain technical specifications for each of their products, including manual, semi-automatic and automatic transmissions. The author then contacted fleet operators who have been using automatic and semi-automatic transmissions for some time in order to perform quantitative and qualitative assessments. The sample was to include both private and public fleets. All fleets involved in the study are headquartered in Quebec but operate throughout Canada.

3.0 Technical Demonstration

In order to better understand the operation of automatic gearboxes, a demonstration was set up with a class 8 truck equipped with a ten-speed transmission and a loaded trailer. This demonstration was arranged through a training centre in the Montréal area and took place at its facility on a closed course. The objective was to test the technology and present it to the client.

4.0 Description of the Various Transmission Types

There are three types of transmissions:

- automatic;
- semi-automatic; and
- manual.

4.1 Automatic Transmissions

With an automatic transmission, there is no clutch pedal; vehicle speed and acceleration determine gear changes, much the same way as in automobiles. This technology has been available for trucks for over 20 years and is used primarily for class 5 and 6 trucks and in city driving conditions.

Unlike automobiles, truck automatic transmissions have no PARK gear. The driver must place the gear selector in neutral (N) when the engine is running and use the parking brake to immobilize the vehicle.

This type of transmission is available for the following trucks:

- **10-wheel tractors**
  - HD-4060P, 6-speed (most recent model);
  - HD-4560, 6-speed;
  - HD-700, 4- and 5-speed.
- **6-wheel tractors**
  - MT 600, 4- or 5-speed;
  - MO3060P, 6-speed;
  - 3560P, 6-speed;
  - 3066P, 6-speed.

Automatic transmissions are available with different controls:

- **Mechanical (lever)**

  The lever-type selector features R, N, D, 4, 3, 2 and 1 positions, selected by pressing a release button and moving the lever to the desired position.

  - **R (reverse):** the vehicle must be fully stopped before selecting this position;
  - **N (neutral):** for starting the engine, for long idling periods and for parking;

- **2–5 or D:** for normal driving conditions;
- **2–3/2–4:** low range for operating under load;
- **2:** for snow-covered roads or steep climbs; and
- **1:** for very slow driving off-highway (rough terrain).

It should be noted that when slowing down or downshifting on slippery surfaces, wheels may lock in first and second gears, causing loss of control.

- **Electronic (push-button)**

  Push-button systems feature R, N, D and MODE. "Up" and "Down" buttons are used where road conditions or traffic requires a lower range than that selected automatically. MODE selects between the "performance" and "economy" programs in the transmission.

- **Keyboard selectors**

  Keyboard selectors may include the following:

  - 1, 2, D, N and R;
  - 1, 2, 3, D, N and R.

Some automatic transmissions allow the driver to monitor system problems at all times during operation. Indicators may show overheating or over-revving. They also tell the driver which gear is engaged and when the retarders have been activated. Warning lights tell the driver when a problem requires servicing.

4.2 Semi-Automatic Transmissions

6, 10 and 18 speeds

With this type of transmission, the driver uses a clutch pedal to put the vehicle in gear and to take it out of gear. The selector has R, N, D, H and L positions.

N with parking brake applied: depress clutch pedal to the floor, start engine, select D, release clutch to engage transmission. The gear selector will automatically change gears based on the engine and vehicle speeds.

R (reverse): the vehicle must be fully stopped before selecting this position.

N (neutral): for starting the engine, for long idling periods and for parking.

D: for normal driving conditions.

H: (manual mode) to upshift and downshift using push buttons.

L: (low mode) to downshift at high engine speed in order to maximize engine braking.

This type of unit is found on the following vehicles:

- **10-wheel tractors**
  - 10-speed;
  - 18-speed.

- **6-wheel tractors**
  - 6-speeds;
  - 10-speeds.

It should be noted that a new generation of semi-automatics without clutch pedals was introduced for class 8 vehicles in the fall of 2000. These transmissions are available in 12- and 16-speed models.

4.3 Manual Transmissions (8-, 10-, 13-, 15- and 18-Speed)

There are a number of gear combinations available for manual transmissions. The most common are 8, 10, 13, 15 and 18 speeds. Contrary to semi-automatics and automatics, there are several suppliers of manual gearboxes.

Manual gearbox: overview

The gearshift lever is used to run through the gears. The choice of gear affects engine performance and must be based on the type of gearbox, the load carried, road conditions and vehicle speed.

Operating a manual gearshift requires special attention to select the right gear at the right time. The driver must know the characteristics of the vehicle's gearbox before setting out on the road.

Double-clutching

Most heavy vehicles have a manual gearbox, requiring a technique called double-clutching. This technique is used to shift both up and down and requires good co-ordination and considerable practice.

Synchronized gearboxes

Manual gearboxes that do not require double-clutching, known as synchronized gearboxes, have recently come onto the North American market. The clutch is operated in the same manner as those on passenger automobiles, i.e. it is always used to change gears.

5.0 Technical Specifications of Transmissions

The following comparison chart illustrates the technical specifications of selected gearboxes. The aim is not to compare all transmissions available on the market, but rather to show the three basic types.

Transmissions: **Manual, Semi-Automatic, Automatic**

		Lever-Operated	Push Button Electronic	Weight Kilograms (Pounds)	Oil Capacity Litres (U.S. Quarts)	Number of Reverse Gears	6-Wheel Tractor	10-Wheel Tractor	Clutch Pedal Used	Electronic Controls	Mechanical Gear Changing	Electronic Gear Changing	Hydraulic Gear Changing
Manual													
6-Speed			✔		161 (356)	18 (19)	1	✔		✔		✔	
10-Speed			✔		273 (602)	22 (23)	2	✔	✔	✔		✔	
18-Speed			✔		325 (716)	26.5 (28)	4		✔	✔		✔	
Semi-Automatic													
6-Speed			✔	✔	191 (422)	18 (19)	1	✔		✔	✔		✔
10-Speed			✔	✔	298 (656)	24.6 (26)	2	✔	✔	✔	✔		✔
18-Speed			✔	✔	335 (738)	26.5 (28)	4		✔	✔	✔		✔
Automatic													
MT 600	5-Speed		✔	✔			1	✔			✔		✔
MO3060P	6-Speed		✔	✔			1	✔			✔		✔
3560P	6-Speed		✔	✔			1	✔			✔		✔
HD-4060P	6-Speed		✔	✔	439 (968)	35 (37)	1		✔		✔		✔
HD-4060	6-Speed		✔	✔	411 (906)	35 (37)	1		✔		✔		✔
HD-700	5-Speed		✔	✔			1		✔		✔		✔

6.0 Owner Surveys

One important phase of this project was to determine the parameters for use and comparison for semi-automatic and manual transmissions. Data were also obtained on automatic transmissions.

Survey 1: **Transport Besner**

The first survey involved a public full-load carrier, Transport Besner. Besner operates 210 tractor units between Newfoundland and Ontario and in some U.S. states. It has been using semi-automatic transmissions for over two years, and its fleet currently includes seven percent semi-automatics, with the rest featuring 13-speed manuals.

Transport Besner has done an in-depth comparison of its various gearboxes, based on two years of operation and over 525 000 km travelled by two vehicles on the Newfoundland–Toronto run, with drivers alternating between trucks with each type of transmission.

Survey Results No. 1

Q: *What was the additional cost for the purchase of a semi-automatic tractor?*

A: Approximately $6,000 over the cost of a manual tractor.

Q: *What is the warranty on the semi-automatic transmission?*

A: A three-year, 480 000-km warranty on parts and labour, with an optional extended warranty.

Q: *What is the warranty on the manual gearbox?*

A: A three-year, 480 000-km warranty on pa ts and labour, with an optional extended warranty.

- Fuel-consumption comparison on identical trip for two types of transmissions – Semi-automatic: **38 L/100 km** (7.5 m.p.g.) Manual: **40 L/100 km** (7 m.p.g.)

Q: *Does the company have a speed policy?*

A: Yes ✔ No __ **90 km/h**

Q: *What is the yearly maintenance cost of a semi-automatic transmission?*

A: The company noted no additional maintenance cost over a manual unit.

- Based on this experience, the company plans to choose semi-automatic transmissions in its new tractors, eventually comprising 90 percent of its fleet.

- The company provides 20 hours of driver training on semi-automatic gearboxes, compared with 40 hours to train a new driver on a manual transmission.

Comment: After both tractors travelled 525 000 km, the semi-automatic model still has its original clutch, whereas the manual tractor has had its clutch replaced twice.

Transmission Survey: **Transport Besner**

	Lever-Operated	Push-Button Electronic	Weight, Kilograms (Pounds)	Oil Capacity, Litres (U.S. Quarts)	Number of Reverse Gears	6-Wheel Tractor	10-Wheel Tractor	Clutch Pedal Used	Electronic Controls	Mechanical Gear Changing	Electronic Gear Changing	Hydraulic Gear Changing
Manual 13-Speed		✔		324 (714)	26.5 (28)	2		✔	✔		✔	
Semi-Automatic 18-Speed	✔	✔		335 (738)	26.5 (28)	4		✔	✔	✔		✔

Survey 2: **Transport Asselin**

The second survey involved another public full-load carrier, Transport Asselin, which operates 100 units between Quebec, Ontario and the U.S., carrying loads of wood chips, sawdust, shavings, logs, lumber and concrete. Transport Asselin has used semi-automatic transmissions for more than nine months. Currently, two of its tractors have semi-automatic transmissions, with the rest being 15- and 18-speed manual transmissions.

Transport Asselin has performed a comparative analysis of the different gearboxes over a nine-month period, based on 177 000 km covered by two vehicles on the Chapais–La Tuque run in Quebec.

Survey Results No. 2

Q: *What was the additional cost for the purchase of a semi-automatic tractor?*

A: $5,500 more than the manual transmission model.

- The semi-automatic transmission has an 800 000-km warranty, parts and labour, as does the manual.
- Fuel consumption of semi-automatic tractor: **51 L/100 km** (5.5 m.p.g.)
- Fuel-consumption comparison on identical trip for both types of transmissions – Semi-automatic: **51 L/100 km** (5.5 m.p.g.) Manual: **51 L/100 km** (5.5 m.p.g.)

Q: *Does the company have a speed policy?*

A: Yes ✓ No _ **90 km/h**

Q: *What is the cost of maintenance?*

A: The company feels it is too early to know the yearly maintenance cost of the semi-automatic; also, it is still under warranty.

- The company intends to have semi-automatics for some runs, but keep the manuals for others.
- **Training** – The company feels one hour of training is enough to introduce semi-automatic transmissions to drivers, whereas three hours are required to train a driver with five years' experience on the manual.

Transmission Survey: **Transport Asselin**

	Lever-Operated	Push-Button Electronic	Weight, Kilograms (Pounds)	Oil Capacity, Litres (U.S. Quarts)	Number of Reverse Gears	6-Wheel Tractor	10-Wheel Tractor	Clutch Pedal Used	Electronic Controls	Mechanical Gear Changing	Electronic Gear Changing	Hydraulic Gear Changing
Eaton Fuller (Manual) 15-Speed		✔		316 (696)	26.5 (28)	2		✔	✔		✔	
Semi-Automatic 18-Speed		✔	✔	335 (738)	26.5 (28)	4		✔	✔	✔		✔

Survey 3: **Molson Breweries, Quebec Region**

The third survey involved a private carrier, Molson Breweries, which operates 270 units in Quebec. Molson has been using semi-automatic and automatic transmissions for more than seven months and presently has 18 such tractors, with the rest of its fleet equipped with hydraulic 6-speed and manual 15-speed transmissions.

Molson has carried out a comparative analysis of the different gearboxes. Its study covered seven months and involved 18 vehicles travelling over more than 60 000 km. The vehicles are used to deliver beer throughout Quebec from Montréal.

SURVEY RESULTS No. 3

- The cost of purchasing a semi-automatic vehicle is $4,500 more than that of a manual tractor.
- The warranty on the semi-automatic is for five years or 1 200 000 km (750 000 miles) on parts and labour.
- The additional cost of an automatic tractor is $20,000, with a five-year or 1 200 000 km (750 000 miles) parts and labour warranty.
- Fuel consumption for a semi-automatic tractor is 46.4 L/100 km (6.09 m.p.g.)
- Fuel consumption for a manual tractor is the same: 46.4 L/100 km (6.09 m.p.g.)
- No fuel consumption data are available for a fully automatic tractor.

Q: *Does the company have a speed policy?*

A: Yes ✔ No __ **90 km/h** for city driving, **95 km/h** for long-distance.

- No data are available on annual maintenance costs of the semi-automatic, as the warranty is still in effect.

CONTINUED...

- Drivers were trained for one hour on the semi-automatic and automatic transmissions, compared to four hours for the manual.

Comment: The company is satisfied with the performance of this technology.

Transmission Survey: **Molson Breweries**

	Lever-Operated	Push-Button Electronic	Weight, Kilograms (Pounds)	Oil Capacity, Litres (U.S. Quarts)	Number of Reverse Gears	6-Wheel Tractor	10-Wheel Tractor	Clutch Pedal Used	Electronic Controls	Mechanical Gear Changing	Electronic Gear Changing	Hydraulic Gear Changing
Manual 15-Speed		✔		316 (696)	26.5 (28)	2		✔	✔		✔	
Semi-Automatic 18-Speed	✔	✔		335 (738)	26.5 (28)	4		✔	✔	✔		✔
Automatic 6-Speed	✔	✔		439 (968)	35 (37)	1		✔		✔		✔

7.0 Technical Observations

A comparative analysis of the different truck fleets provided technical parameters enabling comparisons based on the following:

Difference in cost at purchase

Semi-automatic transmissions have a higher purchase price. The amount varies from fleet to fleet, but the difference appears to be around five percent.

Mechanical maintenance

As these transmissions are relatively new to the market, it was not possible to verify mechanical maintenance costs. Moreover, as several operators keep their trucks for three to five years on average, maintenance is a secondary issue as the transmissions remain under warranty. One carrier surveyed did point out that mechanical components on the semi-automatic transmission, such as the clutch, needed fewer repairs.

Weight differential

The semi-automatic transmission weighs somewhat more than the manual, but the difference is minimal. For bulk carriers, however, this difference could be a factor.

Optimum operating range (numbers of RPM at which peak torque and power are reached)

No marked differences were observed.

Energy-efficient driving

The study showed that two of the three carriers surveyed saw no change in the energy efficiency level. The third company, which generally carries lighter loads than the other two, reported appreciable gains.

Training

All carriers surveyed have training programs that their drivers must take before operating a semi-automatic transmission. Training varies from one to four hours. All carriers felt that there were benefits to this training. It should be noted that the length of training is 75 percent less than that required for manual transmissions.

8.0 Evolution and Trends

Discussions with manufacturers of semi-automatic, automatic and manual transmissions indicate that the new gearboxes are gaining in popularity and are now found in sectors not thought possible only two years ago.

One manufacturer expected a 100-percent growth in the number of semi-automatics in 2000, for several reasons.

One reason is the scarcity of professional drivers. The new technology is easier to use than conventional manual gearboxes, especially if a majority of a fleet's runs are on roads that are relatively level or have few steep rises. Some drivers are still reticent to try the new technology. To date, experience has shown that drivers begin to appreciate the semi-automatic transmissions after an initial period of resistance.

The second reason is the *potential* gain in energy efficiency. Of the three companies surveyed, only Transport Besner has shown a five-percent gain in energy efficiency for trucks with automatic transmissions. This is a considerable gain. For a road tractor covering an average of 200 000 km per year, this can add up to annual savings of over 5000 liters, which translates into financial savings of over $3,000 per year. Although such results are promising, they are not enough to conclude that automatic transmissions affect the energy efficiency of trucks. Further detailed study is needed to show what the impact of such transmissions is on fuel consumption and greenhouse gas emissions. But the fact remains that automatic transmissions can have a positive impact on the environment.

9.0 Conclusion

It appears that automatic transmission technology is becoming more widely accepted. While it is true that it cannot be adopted for all types of transport, the carriers surveyed had no negative performance aspects to report.

In fact, long-term tests under normal operating conditions have shown that this type of gearbox provides either increased performance or at least the same performance as the manual transmissions. Carriers noted only two major disadvantages of automatic transmissions, compared to manual:

- a slightly higher weight; and
- a higher initial cost.

Because of the scarcity of professional drivers, this technology can offer a solution for some operators. It is therefore important to understand that the energy performance of a heavy truck fitted with an automatic transmission is either superior or identical to that of conventionally equipped vehicles.

Appendices

1 • 2 • 3

APPENDIX 1

Technical Specifications:
Transport Besner – Use over 525 000 km

ROAD TRACTOR: MANUAL TRANSMISSION

Tractor:
City _
Long-distance ✓

Model:
6 X 2 _ 6 X 4 ✓

Year: 1998

On-board computer:
Yes ✓ No _

Engine:
370 HP @ 1850 RPM
Operating range _____–_____ RPM

Retarders:
Yes ✓ No _

Manual gearbox RTLO 146-13:
13-speed

Rear axles: 40 000 lb.

Axle ratio: 4.63

Suspension: Air

Tires:
Size 11R 22.5
Hub-mounted disc-type wheels

GCW:
49 500 kg

ROAD TRACTOR: SEMI-AUTOMATIC TRANSMISSION

Tractor:
City _
Long-distance ✓

Model:
6 X 2 _ 6 X 4 ✓

Year: 1998

On-board computer:
Yes ✓ No _

Engine:
430 HP @ 2100 RPM
Operating range 1400–2100 RPM

Retarders:
Yes ✓ No _

Transmission:
18-speed

Rear axles: 40 000 lb.

Axle ratio: 4.63

Suspension: Air

Tires:
Size 11R 22.5
Hub-mounted disc-type wheels

GCW:
49 500 kg

APPENDIX 2

Technical Specifications:
Transport Asselin – Use over 177 000 km

ROAD TRACTOR: MANUAL TRANSMISSION

Tractor:
City _
Long-distance ✔

Model:
6 X 2 _ 6 X 4 ✔

Year: 2000

On-board computer:
Yes ✔ No _

Engine:
475 HP @ 1700 RPM
Operating range 1200–1550 RPM

Retarders:
Yes ✔ No _

Manual transmission RTO 169-15:
15-speed

Rear axles: 46 000 lb.

Axle ratio: 4.35

Suspension: Air

Tires:
Size 11R 22.5
Hub-mounted disc-type wheels

GCW:
62 000 kg
Type B road train

ROAD TRACTOR: SEMI-AUTOMATIC TRANSMISSION

Tractor:
City _
Long-distance ✔

Model:
6 X 2 _ 6 X 4 ✔

Year: 2000

On-board computer:
Yes ✔ No _

Engine:
475 HP @ 1000 RPM
Operating range 1200–1550 RPM

Retarders:
Yes ✔ No _

Transmission:
18-speed

Rear axles: 46 000 lb.

Axle ratio: 4.35

Suspension: Air

Tires:
Size 11R 22.5
Hub-mounted disc-type wheels

GCW:
62 000 kg
Type B road train

APPENDIX 3

Technical Specifications:
Molson Breweries – Use over 60 000 km

ROAD TRACTOR: MANUAL TRANSMISSION

Tractor:
City _
Long-distance ✓

Model:
6 X 2 _ 6 X 4 ✓

Year: 1998

On-board computer:
Yes ✓ No _

Engine:
430 HP @ 2100 RPM
Operating range 1300–1750 RPM

Retarders:
Yes ✓ No _

Manual transmission RTO 156-15:
15-speed

Rear axles: 46 000 lb.

Axle ratio: 4.56

Suspension: Air

Tires:
Size 11R 24.5
Hub-mounted disc-type wheels

GCW:
55 000 kg

ROAD TRACTOR: SEMI-AUTOMATIC TRANSMISSION

Tractor:
City ✓
Long-distance _

Model:
6 X 2 _ 6 X 4 ✓

Year: 2000

On-board computer:
Yes ✓ No _

Engine:
380/430 HP @ 2100 RPM
Operating range 1300–1750 RPM

Retarders:
Yes ✓ No _

Semi-automatic transmission:
18-speed

Rear axles: 46 000 lb.

Axle ratio: 4.33

Suspension: Air

Tires:
Size 11R 22.5
Hub-mounted disc-type wheels

GCW:
55 000 kg

ROAD TRACTOR: AUTOMATIC TRANSMISSION

Tractor:
City ✔
Long-distance _

Model:
6 X 2 ✔ 6 X 4 _

Year: 1991

On-board computer:
Yes _ No ✔

Engine:
245 HP @ 2600 RPM
Operating range 1700–2600 RPM

Retarders:
Yes _ No ✔

Allison transmission:
6-speed

Rear axles: 23 000 lb.

Axle ratio: 5.27

Suspension: Air

Tires:
Size 11R 22.5
Spoke wheels

GCW:
36 500 kg

ROAD TRACTOR: AUTOMATIC TRANSMISSION

Tractor:
City ✔
Long-distance _

Model:
6 X 2 ✔ 6 X 4 _

Year: 1995

On-board computer:
Yes _ No ✔

Engine:
275 HP @ 2600 RPM
Operating range 1700–2600 RPM

Retarders:
Yes _ No ✔

Transmission:
6-speed

Rear axles: 23 000 lb.

Axle ratio: 5.27

Suspension: Air

Tires:
Size 11R 22.5
Spoke wheels

GCW:
36 500 kg

ROAD TRACTOR: AUTOMATIC TRANSMISSION

Tractor:
City _
Long-distance ✓

Model:
6 X 2 _ 6 X 4 ✓

Year: 1997

On-board computer:
Yes _ No ✓

Engine:
300 HP @ 2100 RPM
Operating range 1300–1700 RPM

Retarders:
Yes ✓ No _

Allison transmission:
6-speed

Rear axles: 40 000 lb.

Axle ratio: 5.27

Suspension: Air

Tires:
Size 11R 22.5
Hub-mounted disc-type wheels

GCW:
36 500 kg

Notes

Leading Canadians to Energy Efficiency at Home, at Work and on the Road

The Office of Energy Efficiency of Natural Resources Canada strengthens and expands Canada's commitment to energy efficiency in order to help address the challenges of climate change.

Canada